US008140734B2

(12) **United States Patent**
Lou et al.

(10) **Patent No.: US 8,140,734 B2**
(45) **Date of Patent: *Mar. 20, 2012**

(54) **ASYNCHRONOUS/SYNCHRONOUS SWITCHING OF CONSOLE DEVICES AND PERIPHERAL DEVICES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 207 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/341,717**

(22) Filed: **Dec. 22, 2008**

(65) **Prior Publication Data**

US 2009/0106477 A1 Apr. 23, 2009

Related U.S. Application Data

(63) Continuation of application No. 11/727,333, filed on Mar. 26, 2007, now Pat. No. 7,472,217, which is a continuation of application No. 11/204,036, filed on Aug. 16, 2005, now Pat. No. 7,340,556, which is a continuation of application No. 10/065,375, filed on Oct. 10, 2002, now Pat. No. 6,957,287.

(60) Provisional application No. 60/338,071, filed on Nov. 9, 2001.

(51) **Int. Cl.**
G06F 13/00 (2006.01)

(52) **U.S. Cl.** **710/316**; 710/72; 710/317; 710/64

(58) **Field of Classification Search** 710/305–317, 710/62–64, 72–73, 8–19; 709/227–232
See application file for complete search history.

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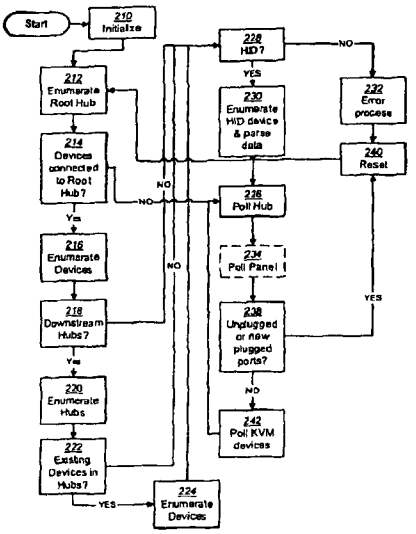
(57) **ABSTRACT**

A signal switch for sharing a video monitor, a plurality of console devices compliant with an industry standard and one or more than one peripheral device in any of a plurality of computer systems, is provided comprising a CPU with a first memory for storing a management program for managing the signal switch; a hub switch module connected to the CPU and configured to communicate with any of the plurality of computer systems, and the one or more than one peripheral device; a device control module for emulating according to the industry standard the plurality of console devices, connected to the CPU and the hub switch module; a host control module connected to the CPU and configured to communicate with the plurality of console devices; and a video control module connected to the CPU and configured to communicate with a video monitor device.

27 Claims, 5 Drawing Sheets



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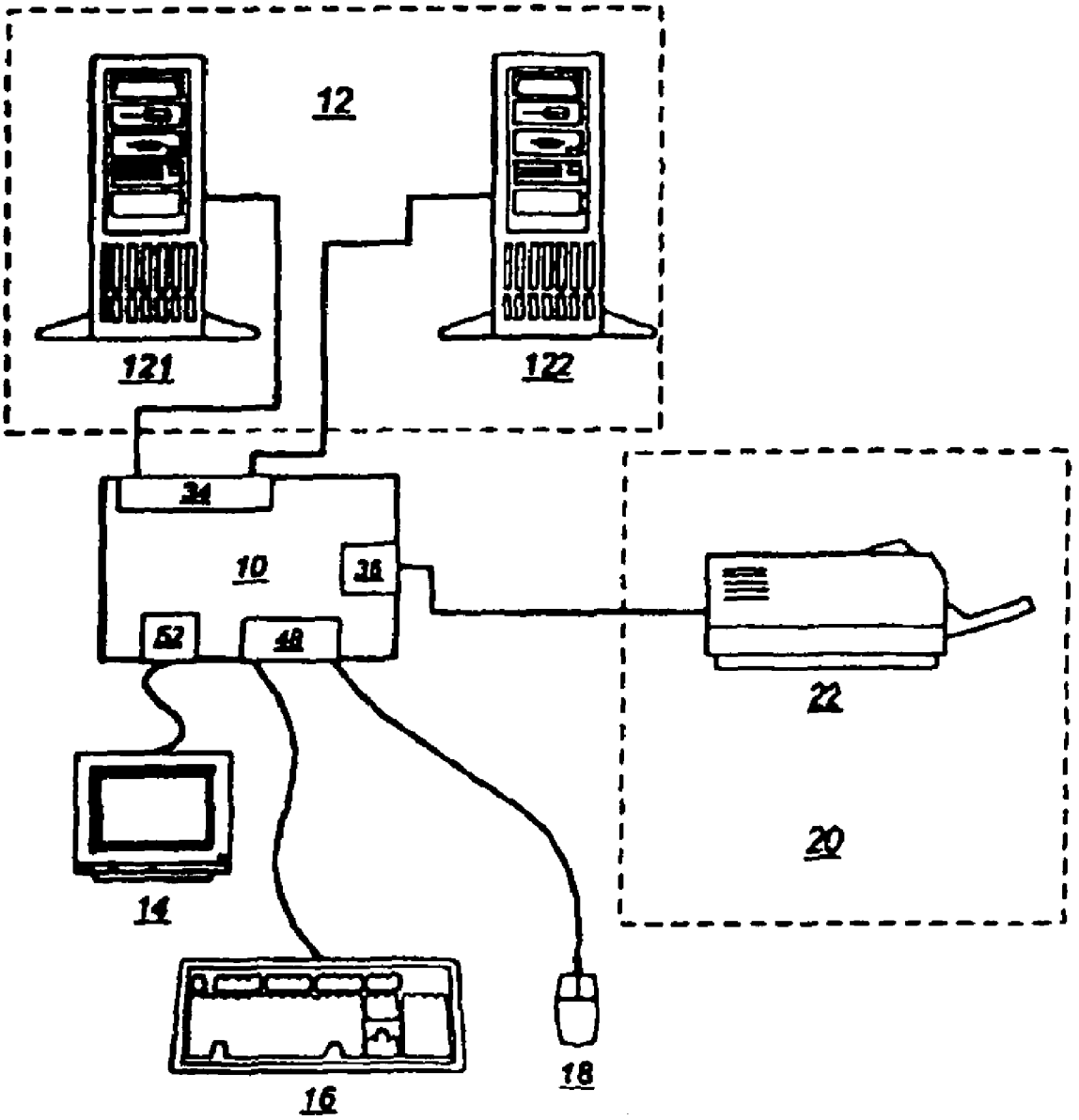

Fig. 1

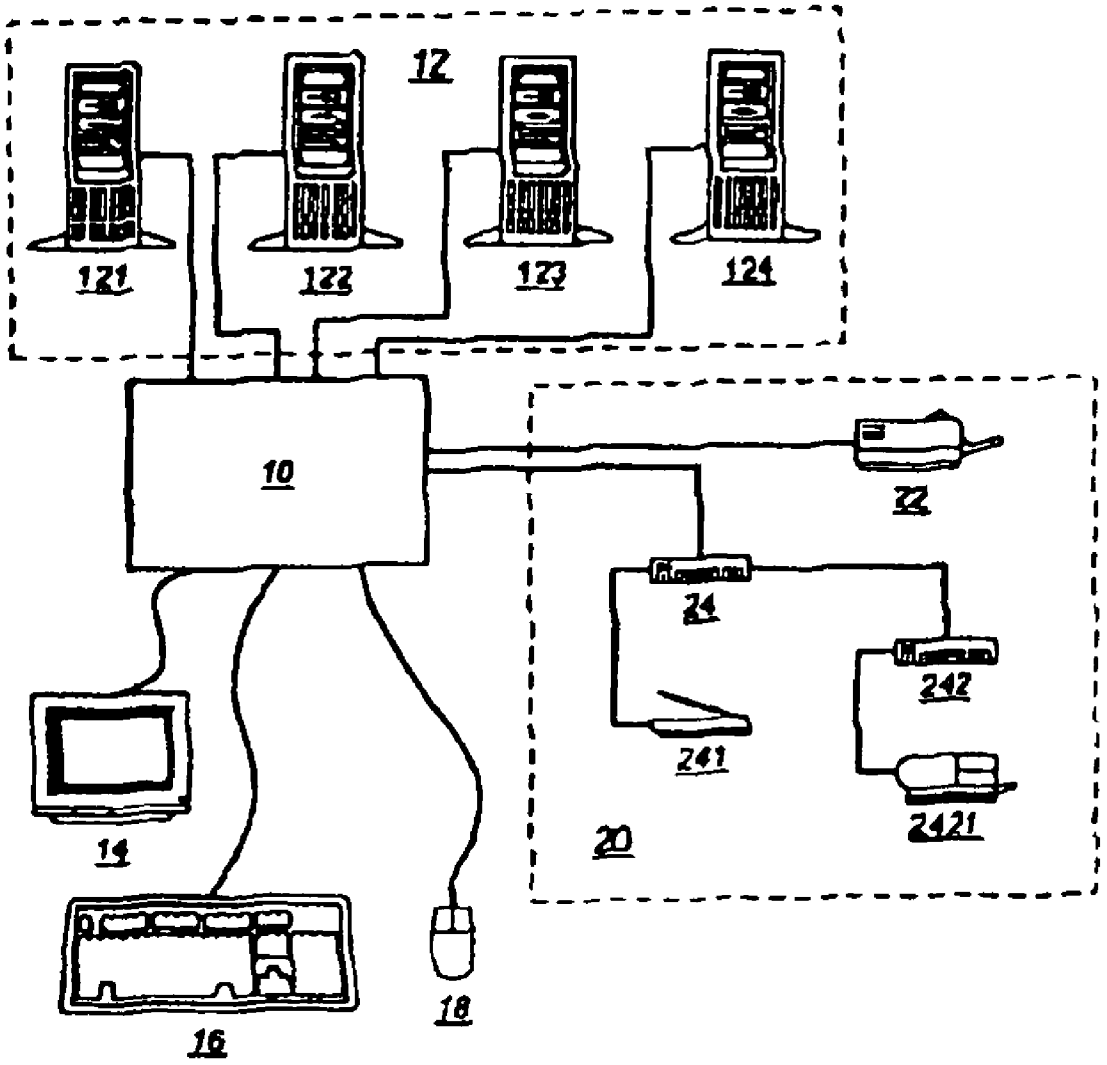

Fig. 2

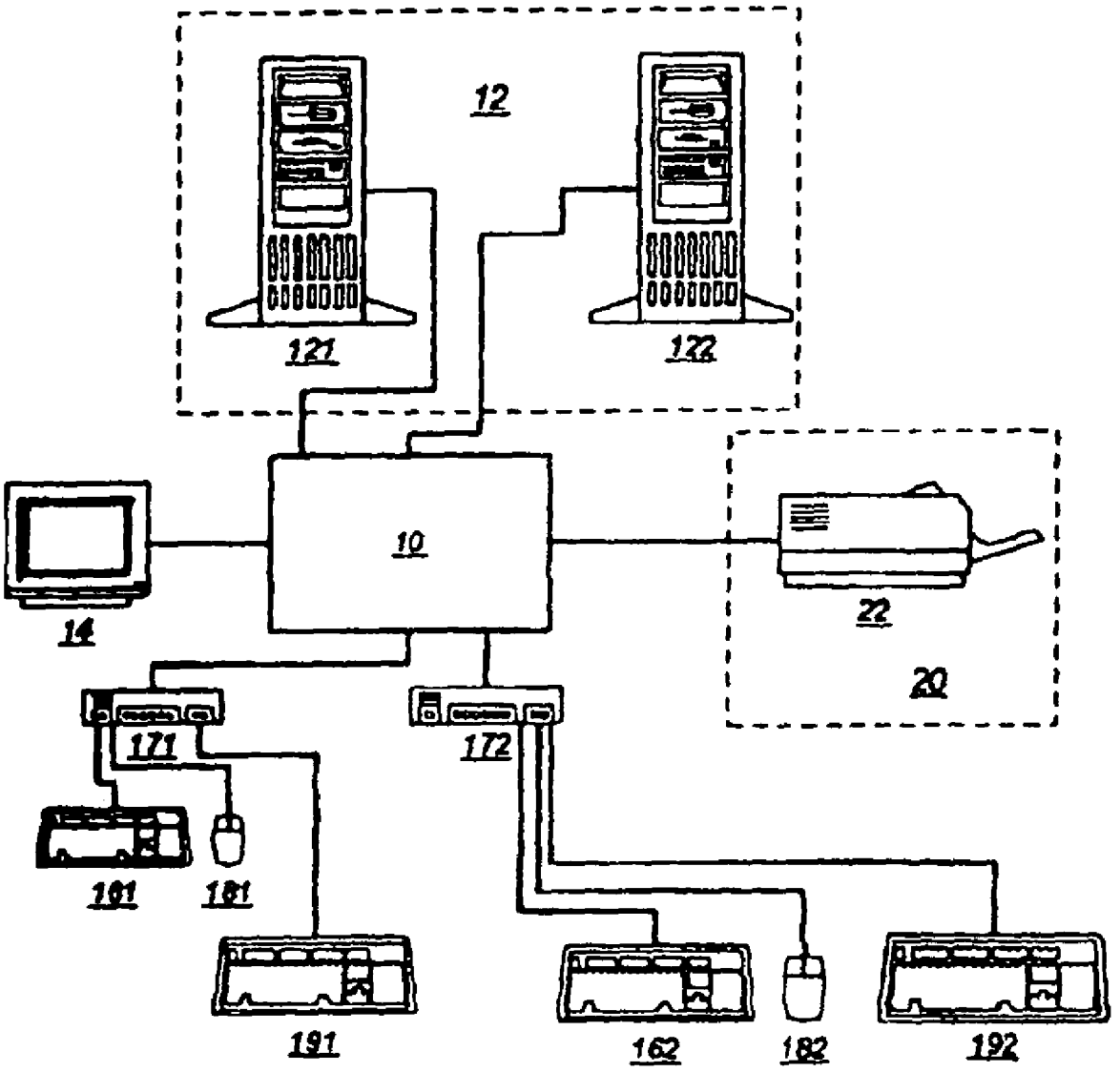

Fig. 3

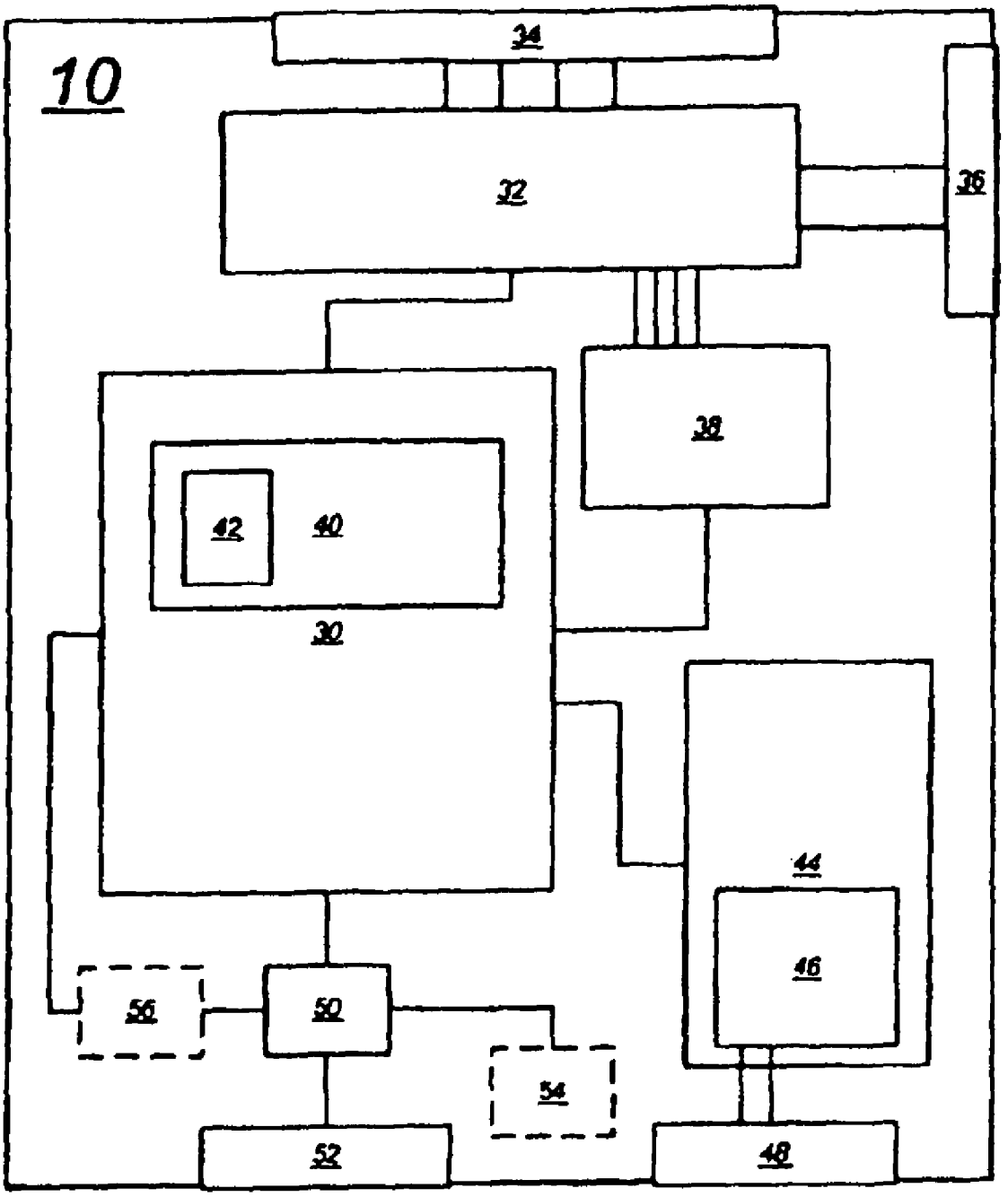

Fig. 4

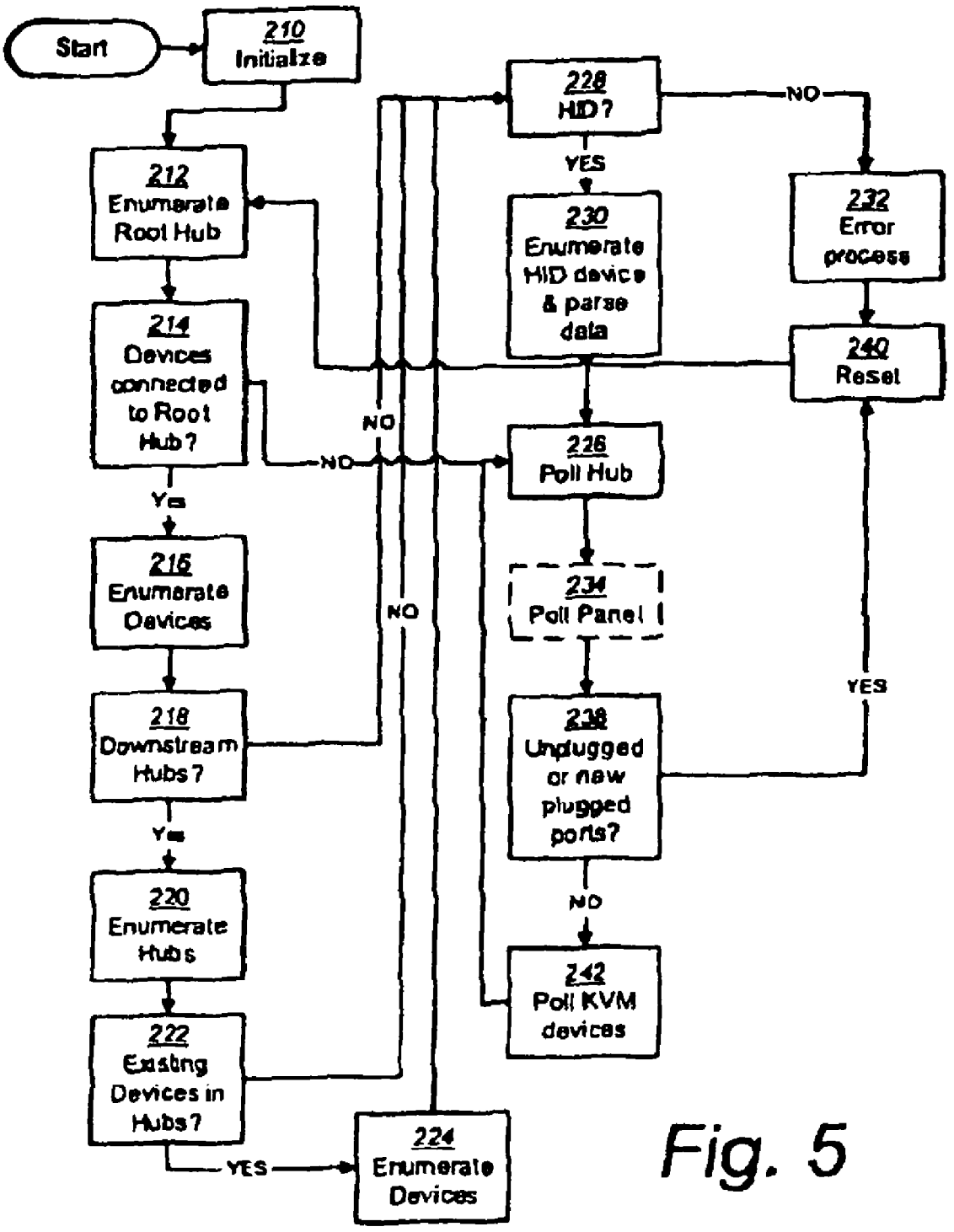
Start
210 Initialize
212 Enumerate Root Hub
214 Devices connected to Root Hub?
Yes
216 Enumerate Devices
218 Downstream Hubs?
Yes
220 Enumerate Hubs
222 Existing Devices in Hubs?
YES
224 Enumerate Devices
NO
NO
NO
228 HID?
YES
NO
230 Enumerate HID device & parse data
232 Error process
240 Reset
226 Poll Hub
234 Poll Panel
238 Unplugged or new plugged ports?
YES
NO
242 Poll KVM devices

Fig. 5

ASYNCHRONOUS/SYNCHRONOUS SWITCHING OF CONSOLE DEVICES AND PERIPHERAL DEVICES

This application is a continuation of U.S. application Ser. No. 11/727,333, filed Mar. 26, 2007, now allowed, which is herein incorporated by reference in its entirety. U.S. application Ser. No. 11/727,333 is a continuation of U.S. application Ser. No. 11/204,036, filed Aug. 16, 2005, now U.S. Pat. No. 7,340,556, which is in turn a continuation of U.S. application Ser. No. 10/065,375, filed Oct. 10, 2002, now U.S. Pat. No. 6,957,287, which claims priority from U.S. Provisional Application No. 60/338,071, filed Nov. 9, 2001.

CROSS REFERENCE TO RELATED APPLICATIONS

The present Application claims the benefit of U.S. patent application Ser. No. 11/204,036 titled "Asynchronous/Synchronous Electronic USB KVMP Switch" filed Aug. 16, 2005; the contents of which are incorporated by reference in this disclosure in their entirety.

BACKGROUND OF INVENTION

A single-user or multi-user keyboard-video-mouse ("KVM") switch system is a signal switch that allows a single user or multiple users to share just a single keyboard, video device and mouse, or multiple sets of keyboards, video devices and mice.

A problem with current KVM switches is that if a USB peripheral, such as a printer, is connected to the switch, data flow is interrupted to that peripheral when the switch is changed.

Universal Serial Bus (USB) is a communications architecture that gives a personal computer (PC) the ability to interconnect a variety of devices using a simple cable. The USB is actually a two-wire serial communication link that runs at either 1.5 or 12 megabits per second (Mbps). USB protocols can configure devices at startup or when they are plugged in at run time. These devices are broken into various device classes. Each device class defines the common behavior and protocols for devices that serve similar functions.

The most current information concerning the USB standard is maintained at the following site on the World Wide Web: http://www.usb.org. Available at that source are the Universal Serial Bus (USB) Specification, the USB HID Usage Supplement, and the Device Class Definition for Human Interface Devices (HID). The HID class consists primarily of devices that are used by humans to control the operation of computer systems. Typical examples of HID class devices include: keyboards and pointing devices—for example, standard mouse devices, trackballs, and joysticks; front-panel controls—for example: knobs, switches, buttons, and sliders; controls that might be found on devices such as telephones, VCR remote controls, games or simulation devices—for example: data gloves, throttles, steering wheels, and rudder pedals; and devices that may not require human interaction but provide data in a similar format to HID class devices—for example, bar-code readers, thermometers, or voltmeters.

What is needed is a KVM switch that is also a peripheral sharing switch, which would allow all the computers connected to the switch to share any USB peripheral devices without interruption of data flow to that peripheral when the switch is changed, and which would switch the KVM channels and peripheral channels to a common computer or to different computers either asynchronously or synchronously.

SUMMARY OF INVENTION

The present invention meets this need by providing a KVM switch that is also a peripheral sharing switch, which allows all the computers connected to the switch to share any USB peripheral devices, and which can switch the KVM channels and peripheral channels to a common computer or to different computers either asynchronously or synchronously without interruption of data flow to that peripheral when the switch is changed. USB peripherals may be synchronously or asynchronously switched with the KVM channels.

The present invention, USB KVMP, allows multiple USB keyboards and multiple USB mice communicating with a common computer at the same time. The USB KVMP provides multiple USB peripheral channels to users and those channels can be connected with all kinds of USB peripherals, such as a USB hub, USB printer, USB scanner, USB camera, etc.

A signal switch is disclosed for sharing a video monitor, a plurality of console devices and one or more than one peripheral device in any of a plurality of computer systems, comprising a CPU comprising a first memory for storing a management program for managing the signal switch; a hub switch module connected to the CPU and configured to communicate with any of the plurality of computer systems, and the one or more than one peripheral device, such that a signal passing from the hub switch module to the one or more than one peripheral device emulates origination from a computer; a device control module for emulating the video monitor and plurality of console devices, connected to the CPU and the hub switch module; a host control module connected to the CPU and configured to communicate with the plurality of console devices; and a video control module connected to the CPU and configured to communicate with a video monitor device.

In a further embodiment, the signal switch further comprises an OSD control device connected to the CPU and the video control module.

In a preferred embodiment the host control module comprises a root hub, the plurality of console devices and one or more than one peripheral device are USB compliant, and the console devices comply with an industry standard specification.

A method is described for sharing a video monitor, a plurality of console devices compliant with an industry standard and one or more than one peripheral device in any of a plurality of computer systems through a signal switch, comprising: initializing the signal switch; emulating one or more of the console devices according to the industry standard; enumerating ports of a root hub; determining whether any downstream ports exists, and if so, enumerating the downstream ports; determining whether any of the plurality of console devices is connected to the root hub, or any downstream ports, and if so, then enumerating each connected device; determining whether any of the connected devices is compliant with the industry standard; enumerating each complaint connected device and parsing any data from such device; and repeatedly polling to determine whether any of the plurality of console devices, any of the one or more than one peripheral device, or any downstream port, has been plugged or unplugged, and if so, resetting control.

In one preferred embodiment, the management program comprises steps for managing the signal switch, and the described method.

A signal switch is described for sharing one or more console devices and one or more peripheral devices in any of a plurality of computer systems, comprising: a first channel for connecting a selected console device from the one or more console devices to a first selected computer system from the plurality of computer systems; a second channel connecting the first selected computer system to a selected peripheral device from the one or more peripheral devices, the second channel having a data flow between the first selected computer system and the selected peripheral device; a third channel for connecting the selected console device to a second selected computer system from the plurality of computer systems; and means for switching the selected console device between the first channel and the third channel without interruption of the data flow through the second channel between the first selected computer system and the selected peripheral device.

BRIEF DESCRIPTION OF DRAWINGS

These and other features, aspects, and advantages of the present invention will become better understood with reference to the following description, appended claims, and accompanying drawings, where:

FIG. **1** is a system diagram of one possible use of the use of signal switch of FIG. **4**.

FIG. **2** is a system diagram of another possible use of the use of signal switch of FIG. **4**.

FIG. **3** is a system diagram of another possible use of the use of signal switch of FIG. **4**.

FIG. **4** is a block diagram of the signal switch of the present invention.

FIG. **5** is a function block diagram of process useable as a management control program for the signal switch of FIG. **4**.

DETAILED DESCRIPTION

The present invention is directed to a signal switch for sharing one or more than one video monitor, keyboard, mouse and peripheral device. The signal switch of the present invention is the combination of a KVM (keyboard video mouse) switch and a peripheral sharing switch. KVM switches are well known in the art with reference to this disclosure. The signal switch according to the present invention allows all computers connected to the switch to share all USB peripheral devices connected to the switch.

The signal switch can either asynchronously or synchronously switch KVM channels and peripheral channels to a common computer or different computer. In other words, the KVM channels and peripheral channels may be switched together (synchronously) or separately (asynchronously).

The present invention utilizes USB emulation programs to emulate the HID (Human Interface Devices) specification, thereby enabling a switch to communicate with the USB ports of PCs, and through USB host emulation programs, enable a switch to communicate with USB devices such as USB keyboards and USB mice, and a USB hub. In other words, the use of emulation makes a switch appear as a computer to peripheral devices, and enables the switch to communicate with USB devices or USB PCs at the same time.

Although an embodiment is described with reference to the current HID specification, it will be apparent to those skilled in the art with reference to this disclosure that the invention may be implemented with any specification for device interfacing.

FIG. **1** illustrates one of the many ways in which the present invention may be used. In a simple configuration, a signal switch **10** according to the present invention permits a user to control a plurality of computer systems **12** (represented by first computer **121** and second computer **122**), and USB compatible peripherals **20** (as shown by first printer **22**) with a monitor **14**, first keyboard **16**, and first mouse **18**. In this example, control of the peripheral first printer **22** can be maintained by computer **121** even while monitor **14**, first keyboard **16** and first mouse **18** are controlling computer **122**. This is because switch **10** can switch between a first channel (not shown) connecting monitor **14**, first keyboard **16** and first mouse **18** to first computer **121** and a third channel (not shown) connecting monitor **14**, first keyboard **16** and first mouse **18** to second computer **122**, while maintaining a second channel (not shown) connecting first computer **121** to first printer **22** such that a first data flow between first computer **121** and first printer **22** is not interrupted.

With reference to FIG. **2**, a more robust use is shown permitting a user to control a larger number of computer systems **12** (represented by first computer **121**, second computer **122**, third computer **123**, and fourth computer **124**), and USB compatible peripherals **20** with monitor **14**, first keyboard **16**, and first mouse **18**. Note that with the present invention it is possible to have one or more than one USB hub **24** also connected to signal switch **10**, which in turn can connect to one or more than one further peripherals such as scanner **241**, or one or more than one downstream hub **242**, which in turn may be connected to one or more than one peripherals such as second printer **2421**. It thus can be seen that any desired tree of hubs/peripherals can be connected to signal switch **10** and thus controlled synchronously or asynchronously by the one or more than one computer systems **12** under the management of a single set of monitor **14**, first keyboard **16**, and first mouse **18**.

Thus, for example, the first data flow between first computer **121** and first printer **22**, a second data flow between third computer **123** and scanner **241**, and a third data flow between fourth computer **124** and second printer **2421** all could be maintained without interruption while keyboard **16** and mouse **18**, and optionally monitor **14**, are switched among computer systems **12**.

Peripheral devices that can be connected with the present invention include but are not limited to a USB hub, printer, scanner and camera. Other examples of peripherals will be understood by one skilled in the art with reference to this disclosure.

With reference to FIG. **3**, In a still further use of the present invention, by way of example it is possible to connect multiple KM devices such as second keyboard **161**, third keyboard **162**, second mouse **181**, second mouse **182**, first composite KM device **191** and second composite KM device **192**. Preferably, since a signal switch usually only has two USB console ports, one or more than one downstream hub may be connected, such as first downstream hub **171** and second downstream hub **172**, to which may be connected one or more than one KM devices.

With reference to FIG. **4**, the signal switch **10** comprises a central processing unit ("CPU") **30** for managing the signal switch **10**. A USB hub switch module **32** is connected to the CPU **30** and is configured to communicate with a plurality of computer systems **12** through first output ports **34**. The USB hub switch module **32** is also configured to communicate with peripheral devices **20** through output ports **36**. In FIG. **4**, four connections are shown between first output ports **34** and the USB hub switch module **32**, but this is by way of example only. The number of connections will equal the number of computer systems **12** for which the signal switch **10** is configured.

Likewise, in FIG. **4**, two connections are shown between second output ports **36** and the USB hub switch module **32**, but this is also by way of example only. The number of connections will equal the number of peripheral output ports for which the signal switch **10** is configured.

The USB hub switch module **32** is a bridge between peripheral devices **20** and computer systems **12** and allows the signal switch **10** to connect each of a plurality of computer systems to one or more than one peripheral device. Construction of a circuit suitable as a USB hub switch module is well known in the art with reference to this disclosure. In one preferred embodiment, the USB hub switch module includes 4 USB hubs and matrix analog switches which are controlled by CPU firmware. Texas Instruments® manufactures USB Hub chips that are suitable for this module, and the module can be constructed using Application Specific Integrated Circuit (ASIC) design methodology.

A USB device control module **38** for controlling signals is connected to the CPU **30** and the USB HUB switch module **32**. The USB device control module **38** comprises USB device chips that are used to emulate the console devices, such as first keyboard **16** and first mouse **18**, for the first output ports **34**. In other words, by having a USB device chip emulate console devices attached to a first computer system, actual console devices may be switched to a second or different computer system, leaving any channels between the first computer system and peripherals connected, any data flow in such channels uninterrupted, and the first computer system still processing as if the actual console devices, now emulated, were still connected. These chips are controlled by CPU **30** firmware. One device chip is required for each computer system **12**. Construction of a circuit suitable as a USB device control module is well known in the art with reference to this disclosure.

In FIG. **4**, four connections are shown between the USB device control module **38** and the USB hub switch module **32**, but this is by way of example only. The number of connections will equal the number of computer systems **12** for which the signal switch **10** is configured. In one preferred embodiment, the USB device control module includes 4 USB device chips and the chips are also controlled by CPU firmware. Philips Semiconductors® makes chips suitable for use in this module, and the module may also be constructed using Application Specific Integrated Circuit (ASIC) design methodology.

Referring to FIG. **4**, the CPU **30** comprises a first memory **40** for storing a management program **42** for managing the operation of the signal switch **10**. A flowchart of the function of a portion of management program **42** suitable for use in the present invention is illustrated in FIG. **5**, and described below.

A USB host control module **44** is configured to communicate with a plurality of console devices and is connected to the CPU **30**. Construction of a circuit suitable as a USB host control module is well known in the art with reference to this disclosure. The USB host control module **44** itself comprises a root hub **46** for communicating with one or more than one console devices or downstream hubs, through third output ports **48**. The root hub is a USB compatible hub, which is well known in the art with reference to this disclosure.

As shown in FIG. **3**, one or more than one downstream hub may be connected to the signal switch **10**, such as first downstream hub **171** and second downstream hub **172**, communicating with root hub **46** through one of the third output ports **48**. It is possible to daisy chain up to 127 devices by adding more downstream hubs.

Typically, third output ports **48** comprise two physical ports. Optionally, in a different embodiment, an Internal additional console USB hub (not shown) may be connected to the root hub **46** for increasing the number of third output ports **48** available for connecting console devices. The CPU **30** firmware has the ability to handle hub functions. Construction of firmware suitable to run the CPU according to the method disclosed herein is known in the art with reference to this disclosure.

An optional video/panel control device module **50** is connected to the CPU **30** for communicating with a variety of optional panel display devices **54** (shown in broken lines), such as light panels, LEDs, buttons, video controller switches, or other optional panel devices. If an on screen display ("OSD") function is provided, then an optional OSD control device module **56** (shown in broken lines) is connected to the CPU **30** and the video/panel control device module **50** for controlling and adjusting signals to an external monitor **14** through fourth output port **52**. Construction of circuits suitable for use as a video/panel control device module or optional OSD control device module is known in the art with reference to this disclosure.

With reference to FIG. **5**, the process of a portion of a management program **42** suitable for use in the present invention may proceed as follows. In step **210** the signal switch **10** is initialized. In step **212**, a root hub **46** is enumerated and any root hub message from the root hub **46** is saved. In step **214** it is determined whether any device is connected to the root hub **46**. If a device is determined to be connected to the root hub **46**, program process passes to step **216**, else the process passes to step **226**.

In step **216**, each device determined to be connected to the root hub **46** is enumerated, and a device message from the USB device determined to be connected to the root hub **46** is parsed and saved in a suitable memory.

Next, in step **218**, it is determined whether any downstream hub is connected to the root hub **46**. If no downstream hub is determined to be connected to the root hub **46**, the process proceeds to step **228**. If a downstream hub is detected, the process passes to step **220**. In step **220** each downstream hub determined to be connected to the root hub **46** is enumerated and a downstream port status of the hub is received. The process then proceeds to step **222**.

In step **222**, it is determined whether any device is existing in a port of the downstream hub. If no device is determined to be existing in a port of the downstream hub, the process proceeds to step **228**. If, in step **222**, a device is determined to be existing in a port of a downstream hub, the process proceeds to step **224** where each such device is enumerated and a connecting device message is parsed and saved in a suitable memory. The process then proceeds to step **228**.

In step **228**, it is determined whether the connected device is a HID keyboard or mouse or other HID compliant device. As will be evident to those skilled in the art with reference to this disclosure, this step could test for compliance with any desired industry standard or device class. If the connected device is not such a device, the process proceeds to step **232** which is an error process which results in resetting a HOST control RAM in step **240**. If the connected device is determined to be complaint, then In the next step **230**, each such connected device is enumerated and its report data is parsed. The reason for the compliance test is that the switch has been constructed to emulate certain console devices which comply with an industry standard device class.

Control then passes to step **226** where the HUB switch module **32** is polled. In optional step **234** any panel or LED circuit is polled. In step **238** it is determined whether any downstream port is unplugged or plugged. If the downstream port is unplugged or plugged the process proceeds to step **240**

where the HOST control RAM is reset. After resetting the HOST control RAM in step **240** the process returns to step **212**. Else, the process proceeds to step **242** where the KVM devices are polled and the process returns to step **234**.

The firmware controls the USB console devices and PC console device emulations. It is not necessary to control the USB peripherals, since the invention generates a path or channel between the USB peripherals and the linked PCs which is undisturbed by switching the channels between the complaint KM devices and the PCs.

Those skilled in the art with reference to this disclosure will be able to construct a USB emulation program suitable for use in the present invention by following the human interface device (HID) specification. The HID specification defines a quasi-language for the HID-compliant USB device to tell the host how to interpret the data that the host receives. This quasi-language is flexible and permits many ways to describe the same piece of functionality. The invention will be useable with other industry standard specifications that define a procedure to tell a host how to interpret the data that the host receives from a standards-compliant device.

Currently, a Device Class Definition for Human Interface Devices (HID) Firmware Specification-Jun. 27, 2001, Version 1.11, is available at http://www.usb.org/developers/data/devclass/HID1.sub.--11.pdf and is incorporated herein. The most current version of the specification and other HID related information is maintained at http://www.usb.org/developers/hidpage.html.

Using a bus analyzer, such as one available currently from Computer Access Technology Corp. it is possible to read the USB bus and analyze the data packets coming from a keyboard and a mouse. The HID specification provides interpretation of the packet meaning. By providing that all the console devices be complaint with the HID specification, or some future standard specification, it is only necessary to emulate such HID or standards-compliant devices.

In a preferred embodiment the whole system programs, which include USB Hub switch control, USB device chip control (device emulation) and console device emulation (Host emulation) are all built in a CPU chip (Flash ROM or PROM). One skilled art with reference to this disclosure and following the referenced specifications will be able to write a USB emulation program suitable to make a switch appear as a PC to peripheral devices, and enable the switch to communicate with USB devices or USB PCs at the same time.

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. It should be appreciated that the present invention should not be construed as limited by such embodiments, but rather construed according to the below claims.

What is claimed is:

1. A signal switch for sharing a video monitor, console devices including a mouse and a keyboard, compliant with an industry standard and one or more than one peripheral device in any of a plurality of computer systems, comprising:

a CPU for managing the signal switch;

a hub switch module connected to the CPU and configured to communicate with any of the plurality of computer systems, and the one or more than one peripheral device,

a device control module for emulating the console devices according to the industry standard, connected to the CPU and the hub switch module;

a host control module connected to the CPU and configured to communicate with the plurality of console devices; and

a video control module connected to the CPU and configured to communicate with the video monitor;

wherein a communication link between the one or more peripheral devices and one of the plurality of computer systems can be maintained even while between the console devices and another one of the plurality of computer systems is established.

2. The signal switch of claim **1**, wherein the hub-switch module comprises at least one hub.

3. The signal switch of claim **1**, wherein the switching circuit comprises at least one switch.

4. A signal switch for sharing one or more console devices and one or more peripheral devices in any of a plurality of computer systems, wherein each console device includes a keyboard, a monitor and a mouse, the signal switch comprising:

a first channel for connecting a selected console device from the one or more console devices to a first selected computer system from the plurality of computer systems;

a second channel connecting the first selected computer system to a selected peripheral device from the one or more peripheral devices;

a third channel for connecting the selected console device to a second selected computer system from the plurality of computer systems; and

a switching circuit configured to switch the selected console device between the first channel and the third channel without changing the second channel connecting the first selected computer system and the selected peripheral device.

5. The signal switch of claim **4**, wherein the one or more peripheral devices include an audio device.

6. The signal switch of claim **4**, wherein the one or more selected peripheral device includes USB (Universal Serial Bus) device.

7. The signal switch of claim **4**, further comprising a device control module connected to the switching circuit for emulating the console devices according to an industry standard.

8. The signal switch of claim **4**, wherein the selected peripheral device is an audio device.

9. The signal switch of claim **4**, wherein the selected peripheral device is a USB device.

10. The signal switch of claim **4**, wherein the switching circuit comprises at least one hub.

11. The signal switch of claim **4**, wherein the switching circuit comprises at least one switch.

12. The signal switch of claim **7**, wherein the device control module emulates the selected console device for the first selected computer system when the switching circuit switches the selected console device from the first channel to the third channel.

13. The signal switch of claim **7**, further comprising a CPU for managing the signal switch, wherein the CPU is connected to the switching circuit and the device control module.

14. A signal switch for sharing one or more console devices and one or more peripheral devices in any of a plurality of computer systems, the signal switch comprising:

a first channel for connecting a selected console device from the one or more console devices to a first selected computer system from the plurality of computer systems;

a second channel connecting the first selected computer system to a selected peripheral device from the one or

more peripheral devices, the second channel having a data flow between the first selected computer system and the selected peripheral device;

a third channel for connecting the selected console device to a second selected computer system from the plurality of computer systems; and

a switching circuit configured to switch the selected console device between the first channel and the third channel without interruption of the data flow through the second channel between the first selected computer system and the selected peripheral device.

15. The signal switch of claim **14**, wherein the one or more peripheral devices include an audio device.

16. The signal switch of claim **14**, wherein the selected peripheral device is an audio device.

17. The signal switch of claim **14**, wherein the one or more peripheral devices include a USB device.

18. The signal switch of claim **14**, further comprising a device control module connected to the switching circuit for emulating the console devices according to an industry standard.

19. The signal switch of claim **14**, wherein the one or more console devices includes a keyboard, a monitor and a mouse.

20. The signal switch of claim **14**, wherein the selected peripheral device is a USB device.

21. The signal switch of claim **18**, wherein the device control module emulates the selected console device for the first selected computer system when the switching circuit switches the selected console device from the first channel to the third channel.

22. The signal switch of claim **18**, further comprising a CPU for managing the signal switch, wherein the CPU is connected to the switching circuit and the device control module.

23. A signal switch for sharing a set of console devices and one or more peripheral devices in any of a plurality of computer systems, comprising:

a first channel for connecting a first console device selected from the set of console devices to a first selected computer system selected from the plurality of computer systems;

a second channel for connecting the first selected computer system to a selected peripheral device selected from the one or more peripheral devices;

a third channel for connecting the first console device to a second selected computer system selected from the plurality of computer systems;

a fourth channel for connecting a second console device selected from the set of console devices to the first selected computer system;

a fifth channel for connecting the second console device to the second selected computer system; and

a switching circuit for switching the set of console devices from the fourth channel to the fifth channel without interrupting data flow of the first channel and the second channel.

24. The signal switch of claim **23**, wherein the first console device is a keyboard and the second console devices is a mouse.

25. The signal switch of claim **23**, wherein the first console device is a mouse and the second console devices is a keyboard.

26. The signal switch of claim **24**, wherein the set of console devices further comprise a third console device.

27. The signal switch of claim **24**, wherein the third console device is a monitor.

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